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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Northeastern Forest Experiment Station

Station Note No. 1
February 14, 1947

610 Bankers Securities Bldg.
Philadelphia 7, Pennsylvania

RELATION OF TREE-STUMP DIAMETER TO DIAMETER BREAST HIGH

By F. E. Cunningham, S. M. Filip, and M. J. Ferree

A large amount of stumpage in the Anthracite Region of Pennsylvania is sold on a stump-diameter basis. Often it has been necessary to estimate the volume cut from a given tract when the only things left to measure were stumps. Since volume tables are generally based on diameters at breast height, timber operators, foresters, and land owners have long felt the need for some way to use these d.b.h. volume tables when the only information they have is stump diameters.

To fill this need, a study of the stump-d.b.h. relationship was made in the Anthracite Region, and stump-d.b.h. tables were developed. Similar work has been done by others but none of the data from these sources were used; it was felt that local measurements would give better results for the region.

Preliminary measurements were taken to determine the effect of site and species on the stump-d.b.h. ratio. Analysis of these data showed that the effect of site is insignificant. However, there are important differences among species; so data were taken for the same species that are listed in the site-class volume tables recently issued. 1/

The data were obtained by measuring nearly 1,000 trees. Diameters were measured to the nearest one-tenth inch with a diameter tape. Measurements were taken at 0.5 foot and 1.0 foot (stump height) and at 4.5 feet (breast height) above ground level. Bark thickness was measured with a Swedish bark gage.

From these data two sets of tables were developed. Analysis shows that they vary not more than 4 percent from true values. Table 1 shows the stump diameter when the d.b.h. is already known. Table 2 shows the d.b.h. when the stump diameter is known. With these tables (in conjunction with d.b.h. volume tables)tree volume can be estimated when the only information available is the size of the stump left after logging.

1/ Burnham, C. F., Ferree, M. J., and Cunningham, F. E. Site Class Volume Tables for Merchantable Timber in the Anthracite Region of Pennsylvania. Forest Management Paper No. 3, Northeast. Forest Expt. Sta. 1946.

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Table 1.--Stump diameters in relation to diameter breast high, by species

(In inches - outside bark)

D.b.h. (Inches, outside bark)	White pine	Eastern hemlock	Pitch pine	White oak	Red oak	Chest-nut oak	White ash	Bass-wood	Yellow poplar	Black cherry	Sugar maple	Red maple	Black & yellow birch	Beech	Aspen
DIAMETER AT 0.5-FOOT STUMP HEIGHT															
5	7	7	7	7	7	7	6	6	6	6	6	6	7	7	6
6	8	8	8	9	8	8	7	7	7	7	7	7	8	8	7
7	9	9	9	10	10	9	9	8	8	8	9	9	10	9	8
8	10	10	10	12	11	11	10	9	9	9	10	10	11	10	9
9	12	12	12	14	13	12	11	11	11	11	11	11	13	12	11
10	13	13	13	16	14	13	13	12	12	12	13	13	14	13	12
11	14	14	14	17	16	14	14	13	13	13	14	14	16	14	13
DIAMETER AT 1-FOOT STUMP HEIGHT															
11	13	13	13	15	14	13	13	12	12	12	13	13	14	13	12
12	14	14	14	16	15	14	14	13	13	13	14	14	15	14	13
13	15	15	15	18	16	16	15	15	15	14	15	15	16	15	15
14	17	17	17	19	18	17	16	16	16	16	16	16	18	17	16
15	18	18	18	21	19	18	17	17	17	17	17	17	19	18	17
16	19	19	19	22	20	20	19	18	18	18	19	19	20	19	18
17	20	20	20	23	22	21	20	20	20	19	20	20	22	20	--
18	22	22	22	25	23	22	21	21	21	20	21	21	23	22	--
19	23	23	--	26	24	24	22	22	22	21	22	22	24	23	--
20	25	25	--	28	26	25	24	23	23	22	24	24	26	25	--
21	26	26	--	29	27	26	25	24	24	23	25	25	--	26	--
22	27	27	--	30	29	28	26	26	26	24	26	26	--	27	--
23	29	29	--	32	30	29	27	27	27	25	27	27	--	29	--
24	30	30	--	33	31	30	29	28	28	26	29	29	--	30	--

Table 2.--Diameters at breast height in relation to stump diameter, by species

(In inches - outside bark)

Stump diameter (Inches, outside bark)	White pine	Eastern hemlock	Pitch pine	White oak	Red oak	Chestnut oak	White ash	Basswood	Yellow poplar	Black cherry	Sugar maple	Red maple	Black & yellow birch	Beech	Aspen
At 0.5 foot height:															
5	4	4	5	4	4	5	4	5	5	5	4	4	4	4	5
6	5	5	6	5	5	5	5	6	6	6	5	5	5	5	6
7	6	6	6	5	6	6	6	6	7	7	6	6	5	6	7
8	7	7	7	6	6	7	7	7	7	7	7	7	6	6	8
9	8	8	8	7	7	8	8	8	8	8	8	8	7	7	9
10	9	9	9	7	8	9	9	9	9	9	8	9	8	8	10
11	10	9	10	8	8	10	9	10	10	10	9	9	8	9	10
12	10	10	11	8	9	11	10	11	11	11	10	10	9	9	11
13	11	11	11	9	10	12	11	11	12	11	11	11	10	10	12
At 1-foot height:															
11	11	10	11	9	10	11	10	11	11	11	10	10	9	10	11
12	12	11	12	9	10	12	11	11	12	11	11	11	10	11	12
13	13	12	13	10	11	12	12	12	13	12	12	12	11	11	13
14	13	13	14	11	12	13	13	13	14	13	13	13	12	12	14
15	14	14	15	12	13	14	14	14	14	14	14	14	13	13	15
16	15	15	15	12	14	15	15	15	15	15	14	15	13	14	16
17	16	15	16	13	14	16	16	16	16	16	15	15	14	15	--
18	17	16	17	14	15	17	17	16	17	17	16	16	15	15	--
19	18	17	18	15	16	18	17	17	18	18	17	17	16	16	--
20	19	18		15	17	18	18	18	19	19	18	18	17	17	--
21	20	19	--	16	18	19	19	19	20	20	19	19	17	18	--
22	20	19	--	17	18	20	20	20	21	21	20	20	18	19	--
23	21	20	--	18	19	21	21	21	21	22	20	20	19	19	--
24	22	21	--	18	20	22	22	21	22	23	21	21	20	20	--
25	23	22	--	19	21	23	22	22	23	24	22	22	21	21	--
26	23	22	--	20	21	24	23	23	24	--	23	23	--	21	--
27	24	23	--	21	22	--	24	24	--	--	24	24	--	22	--
28	--	24	--	21	23	--	--	--	--	--	--	--	--	23	--
29	--	--	--	22	24	--	--	--	--	--	--	--	--	24	--
30	--	--	--	23	--	--	--	--	--	--	--	--	--	--	--

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

N O R T H E A S T E R N F O R E S T E X P E R I M E N T S T A T I O N

Station Note No. 2
April 8, 1947

610 Bankers Securities Bldg.
Philadelphia 7, Pennsylvania

TRENDS AND PROBLEMS OF THE WOOD TURNING INDUSTRY IN THE NORTHEAST

Roy M. Carter*

(Paper Presented at Sixth Vermont Wood Products Conference, Vermont Bureau of Industrial Research, Norwich University, Northfield, Vt. June 1946.)

Hundreds of small communities and towns in the Northeast are dependent upon the wood turning industry. They flourish as the industry progresses, and suffer when it is depressed. The industry is not a large wood consumer but in New England it uses more hardwood than any other industry. Even though wood turning is considered a small industry, the 500 plants in the Northeast are important contributors to the economy of the region.

Wood turning has grown to its present size largely because of the presence of white birch. Insects, disease and heavy cutting have reduced the available supply of birch at an alarming rate. Competition with products made of other material has increased. At the same time manufacturing problems have been hampering production.

The importance of maintaining and improving the position which the turning industry holds in many New England communities is easily recognized. A cooperative study by the Station's Forest Utilization Service and the Forest Products Laboratory has been in progress for some time. Over 50 representative turning mills have been visited. Discussions with the wood turners and observations at the plants were made to determine (1) how and where developments in wood research could be applied and (2) which problems of the industry justify further investigation. This paper summarizes some of our observations and suggests some steps which the industry may want to consider.

The Timber Supply Situation

During the last four years the bronze birch borer has seriously riddled the birch stands in Maine. Entomologists estimate that 75 per cent of the birch in Eastern Maine has been killed by the insect. The amount of

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damage decreases westward to the New Hampshire-Maine state line where 10 to 20 per cent of the birch is dead. The beech scale is causing a similar but less severe loss in the volume of beech. These losses due to insects have been far greater than the annual volume used by the industry.

Plants which depended almost exclusively on white birch have had to increase the use of other northern hardwoods--beech, yellow birch and maple. Some have stuck to white birch. Sooner or later all turning plants will have to use several species in order to maintain or increase their production.

Adequate supplies of timber are less accessible. Quality of the timber is also poorer. Wood procurement is therefore more costly and these costs, including increasing manufacturing costs, make the price of wood turnings higher.

One means of improving the raw material supply situation is through integrated logging. That is, logging which removes all sizes and grades of mature timber and then sorts and distributes the logs to various industries in accordance with the log grade and species required by each. Such logging is thus integrated with the requirements of not one but of all industries in the vicinity. For example, a veneer logging crew would not take only the butt veneer logs but would also cut sawlogs. The portion of the tree above sawlogs would go into pulp or turning bolts. Ash, softwoods and other mature trees not suitable for veneer would also be cut. In this way each company would not have to successively log the same area. More remote tracts of timber could then become operable because loggers could cut a greater merchantable volume per acre. Immature timber could be left for future cutting. The ultimate objectives are: (1) to increase the volume of logs available to a plant; (2) obtain more complete utilization of the low quality logs and the entire merchantable volume in the woods; and (3) to provide each industry with the quality of raw material desired. Several concerns have adopted integrated logging and have made arrangements to exchange logs on a value basis. A greater exchange among industries is possible and should be promoted.

Turneries Face Tough Competition

The real competitor of the turning industry is not the plant producing the same w ood product but the plant making the same item out of material other than wood. Stiff competition has not been felt yet because, at present, the wood turners cannot supply the demand for turnings. This abnormal demand has been met with only a slight expansion among wood turners but the plastics, metal and composition material manufacturers have expanded at a tremendous rate.

Development of plastics during the war years was restricted to military requirements. But now, most uniform, small and smooth products, required in large numbers, that are made of wood are ideal for plastics, metal and composition material manufacturers. In the publication "American Industry Looks Ahead," prepared by the Committee for Economic Development, the

production of plastic materials for 1947 is estimated to increase 161 per cent over that of 1939. Compare that production with all wood products which is estimated to increase only 25 per cent in the same period. The increase in the wood turning industry probably will be less than 25 per cent. In 1940 about 5 million electric irons were produced. In 1946 about 5 million plastic electric iron handles are scheduled for production. Screw driver, chisel and similar handles were once mostly wood. Now observe the new shipments being received in chain stores and other large distributors. Use of wood for toys gained during the war. It is regrettable that the quality of many toys was detrimental to wood. At the Toy Manufacturers' show in New York last March, the demand for wood toys was reported to be one-half of the pre-war level.

Not only is the turning industry faced with diminishing supplies of desirable turning stock but it is also threatened with a loss of markets historically dominated by wood. As business approaches normal and competition with substitute materials really affects the entire industry, the struggle for existence, expecially for the less efficient plants, will become acute. It is therefore vital to the turners in the Northeast to keep abreast of recent developments in manufacturing, to modernize their plants, to assist each other and adopt methods of manufacturing which will enable them to meet this competition.

Manufacturing Problems and Some Suggestions

Every phase of the turning industry presents problems. All turners seem to be interested in decreasing the drying time for both air seasoning and kiln drying. Serious checking of beech has been observed in a number of instances. Discoloration during kiln drying has been a headache in some white birch plants. Some plants need to reduce handling in the yards and also mills. Finishes on turned products sometimes are rough and blistered. Disposal of turning wastes is another problem that continually confronts the mills. Fungus blue stain in squares, and more so in bolt pile held over through the summer causes serious losses. Product standardization of more-or-less-permanent production items is needed. Impregnating, gluing and laminating were other topics of interest to turners. These are only a part of the technical problems confronting the turning industry.

Air Seasoning and Kiln Drying

The most frequent and important topic discussed with the turning industry is air seasoning and kiln drying. This problem is always present. Wide variation exists in sizes and shapes of air seasoning piles. Some are made the easiest way--not the best. Rate of air seasoning is affected by the method of piling, which controls air circulation. For each species and size of turning square there is a type of pile that will give most rapid drying. Several publications have been prepared on the general principles of air seasoning, but more detailed work on the efficiency of several types and methods of piling is needed. Beech is a species which develops serious air seasoning checks in large squares and lumber. To reduce checking in beech of this size, piles should be made to decrease the rate of drying. A project to obtain information on the air seasoning problem is contemplated either in cooperation with industries or schools or both.

Kiln drying is very often the most important operation in the entire plant, especially when production in the mill fluctuates around kiln output. The kiln is one piece of equipment which should be up to date and functioning efficiently. One of the reasons why the turning industry is concerned with kiln drying is because the average kiln in use does not include the improvements of the last 25 years. Forced circulation kilns are now gradually being installed in some plants. A brisk rate of circulation (200 to 400 feet per minute across the load) and automatic control of temperature and humidity are desirable to insure a fast drying rate for green hardwoods. "Automatic" does not infer that a well-trained kiln operator is not necessary. On the contrary, his training is more essential when operating fan kilns than natural circulation of "hot-room" type kilns. Nevertheless, good turnings can be made from green lumber dried in homemade heated compartments if the operator knows how to control drying conditions.

The importance of kiln modification and operation was recognized by wood working plants and others who requested kiln drying training. Field courses are now planned in the Northeast with Forest Products Laboratory kiln engineers providing the instruction. One two-weeks course is scheduled in Maine this fall and others may be held as interest develops.

Considerable information on the types of kilns, kiln operation and drying procedures has been published and is available. Most of these publications refer to long lumber. Two-inch and smaller squares dry easily and much faster than lumber of the same thickness. Stress developed in the wood during drying and shrinkage of squares does not cause serious checking or other defects. Consequently, special schedules are needed for squares. A Forest Products Laboratory kiln is being located at Dixfield, Me., to develop temperature and humidity schedules or guides especially for the turning industry. Test runs will be made on squares of most wood turning species to find the optimum schedule for speed and for whiteness. Promising kiln schedules will then be tried in the cooperator's large commercial kilns. Results, giving recommended (temperature and humidity) drying schedules, will be made available to the entire turning industry.

Handling Turning Stock by Machine vs. Hand Labor

The days of cheap labor are gone. Wood working plants throughout the Northeast could all use more employees. One answer is to obtain greater production with present labor by providing mechanical aids.

Count the number of times turning bolts and squares are moved by hand until they get to the lathe. The bolts are handled three to five times from the truck to the yard to the mill. Flitches at the sawmill are usually handled three times. Squares, from the mill to the yard to the kiln to the lathe, are piled, unpiled, and repiled, often handling each square, at least six times.

With fewer men, conveyors, cranes and numerous devices for handling bolts and logs are reported to increase production and decrease costs of operating wood yards. Bolt ills, equipped with conveyor belts, turn table, active rolls and automatic feeds have shown as much as a 20 per cent in-

crease in production, mainly by eliminating heavy lifting.

Mechanized handling of squares saves even more labor. Squares are piles for seasoning only once on pallets or skids. Fork-lift trucks, hoists or tractor cranes carry the palletized squares to the yard, to the kiln and from the kiln to the lathe without repiling again. This use of lift trucks requires good yard roads, adequate kiln floors and run-ways. Squares may have to be bound or clamped on the lift truck. This is not impractical. A number of mills have been using lift trucks in the yards and more have them on order.

Machining

Unable to obtain sufficient quantities of white birch or the usual species, mills have been forced to fill in with beech, soft and hard maple, aspen or yellow poplar and even gum. Each new species has meant considerable "trial and error" lathe and knife adjustment and machining. For each species and moisture content range there is an optimum feed, speed, depth of cut, knife angle and cutting edge. What these are nobody knows, or if they do know they haven't recorded them. Therefore, as turning plants use new species and invariably encounter poor quality turnings they have no alternative but the "trial and error" method of determining an acceptable machining practice.

Compared with the metal and plastics industries, machining wood is still in the horse and buggy days, although wood was turned long before either competitor was know. Technical book stores all have volumes on machining metal but try and find one on machining wood.

When a man learns set-ups for a metal lathe he refers to tables and charts. During the war, girls were trained in a few days or weeks to operate complicated machines. This was possible because the industry had compiled and determined exact machining procedures. In order to train new woodworking machine operators, it would be desirable to know the technical specifications for machining each species. It would be valuable for the basic design of new turning equipment. A compilation of present machining practices would be helpful. Turning plant machine operators and managers have requested this information. Results would be available to aid the industry. After gathering these data, the need for and type of machining research in laboratories could more readily be determined.

Wastes

A study of wood waste at five turning mills in New England shows that 57 per cent of the solid wood content of a cord of bolts is lost by the time the squares are dried. Another 16 to 38 per cent of the cord is trimmed off in making the finished turning. Thus, only 5 to 27 per cent of the cord which comes out of the woods appears as a toy, a handle, or a spool. Sawdust from squares cut with a 3/16-inch saw averages 12 per cent of the cord. Waste in slabs and edgings (38 per cent) was greater than the volume in the end-product. Cutting out knots, and other defects, seasoning losses and machin-

ing losses range from 16 to 38 per cent.

There are several measures the industry can adopt to reduce this waste. These are as follows:

1. Use the thinnest possible saw in all sawing operations. Experience at one plant shows that the decrease in sawdust and increase in squares paid for a band saw two years after it was installed.

2. Saw squares or flat stock to minimum and uniform size.

3. Season and kiln dry stock without loss due to end checks, surface checks and other seasoning defects.

4. Develop products and methods of converting more of the wood in slabs and edgings into turnings.

5. Don't cut small thrifty immature timber which could produce a larger proportion of clear wood by additional diameter growth.

Turning plants use part of their waste for fuel. There should be better ways of using turning waste from a $22.00 cord than for fuel. Many imperfect turnings can be stained or enameled to cover defects which do not affect serviceability. Discolored, stained stock can be sorted out for specialty items. Other products have been made out of these wastes such as graded sawdusts for fur cleaning, metal cleaning and polishing, composition materials, wood flour, decorations and more recently furniture core stock, wall boards and insulation boards.

Very often one plant's wastes can be raw material for another plant. Trimmed or defective long handle stock may be used by other plants for novelties or short handles. Flat stock too thin for shoe lasts should find a ready market. Ordinarily neither the plant capable of using another's waste nor the mill producing such stock devotes much effort to find each other. A statewide or regional clearing house for exchanging information on wastes could serve a valuable function of bringing producer and buyer together.

The wood turning industry is noted for its rugged individualism, its reluctance to exchange ideas and its inventive ingenuity. However, an industry being threatened with substitute competition, loss of an important species--white birch--and presenting manufacturing problems, part of which come from a lack of modernization, can ill afford to continue isolationism. One of the healthiest indications of the industries' interest in improving manufacture processes is the attendance at this and similar meetings. General acceptance of a united front of the mos t effective practices indicates a progressive industry that can stand competition.

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Northeastern Forest Experiment Station

Station Note No. 3
June 20, 1947

610 Bankers Securities Bldg.
Philadelphia 7, Pennsylvania

A SIMPLIFIED METHOD FOR LOCATING SAMPLE PLOTS ON AERIAL PHOTOGRAPHS

by Fred J. Hartman

Forest inventories made from aerial photographs often require a more or less uniform spacing of sample plots. The forest survey in the Northeast is using such a pattern.

In areas where the differences in relief are great, mountain and ridge tops appear on the photographs at a larger scale than the valleys and lowlands. It is obvious that a uniform plot spacing on the photos will cause the sample plots to be concentrated on these higher elevations. This clustering gives rise to a significant sampling bias, because forest types and stand-sizes on the highlands are seldom the same as those on the lowlands. To lessen this error in plot location, the following method

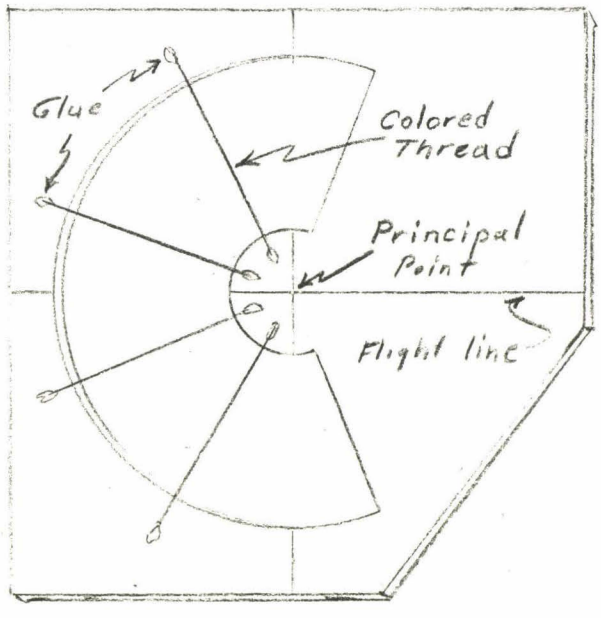

Figure 1.—Celluloid template

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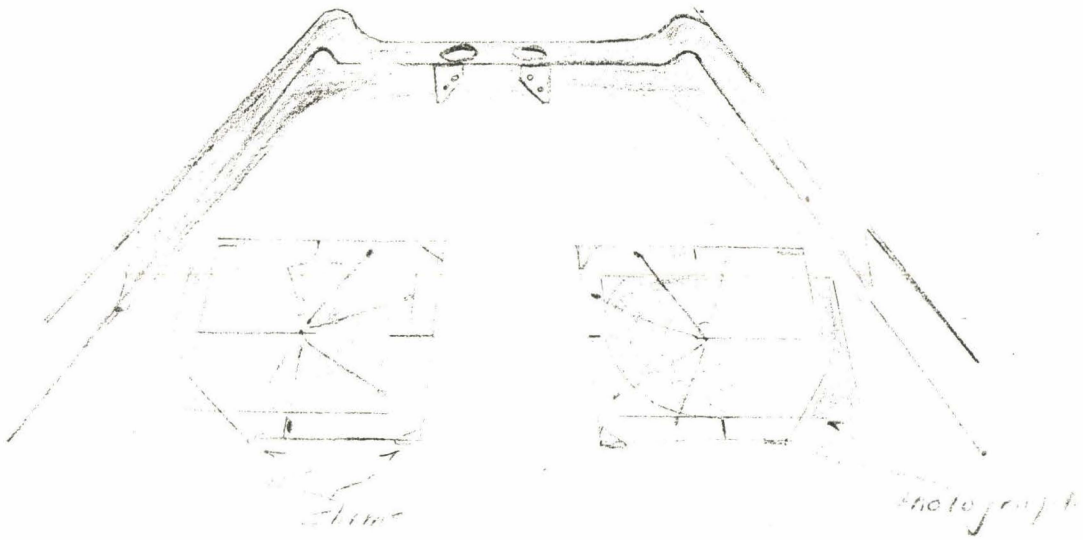


Figure 2.--How templates are used

of locating sample plots on aerial photos was designed for areas where differences in relief are moderate.

After the intensity of the survey (number of plots per photo) has been determined, a convenient spacing design is chosen. This design (square, rectangular, etc.) is drawn on a section of a planimetric map of the area; and all the plots that fall on one stereo-pair of photos are carefully transferred to each photo by inspection. Radial lines are drawn from the center of each photo through each plot.

Then a transparent celluloid template, cut out as shown (fig. 1), is placed over each photo. It is placed so the horizontal line is along the line of flight and intersects the vertical line over the principal point of the photo. With the templates in this position under the stereoscope, the radial lines are marked on the perimeter of the template; and colored threads are fixed on the templates so they coincide with the lines on the photos. It is well to use threads of different colors to distinguish each plot.

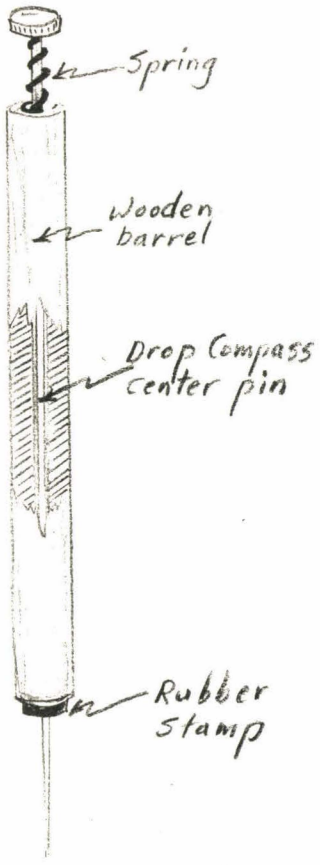


Figure 3.--Tool for marking plots on aerial photos

These spacing templates are used as follows: One is placed under each mirror of the stereoscope. They are mounted on celluloid shims thick enough so that photos may be slid under and oriented (fig. 2). As the photos are viewed stereoscopically under the templates, the apparent intersecting lines present a plot spacing that has minimum relief errors in areas of less than 1,000 feet difference in elevation. The exact location of the plot at the intersection of the threads is marked with a drop compass or a drop-center rubber stamp (fig. 3). Plot positions should be marked on only one photo of a stereo-pair.

This method of locating sample plots is not without error, and was designed for use in areas of less than 1,000 feet difference in elevation. It does, however, eliminate most of the elevational error in less rugged terrain, and it has the advantage of speed--more than 200 plots per hour can be located on aerial photos with this method.

McQuilken

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Northeastern Forest Experiment Station

Station Note No. 4
July 25, 1947

610 Bankers Securities Bldg.
Philadelphia 7, Pennsylvania

TIMBER REQUIREMENTS OF ANTHRACITE MINES

by Miles J. Ferree

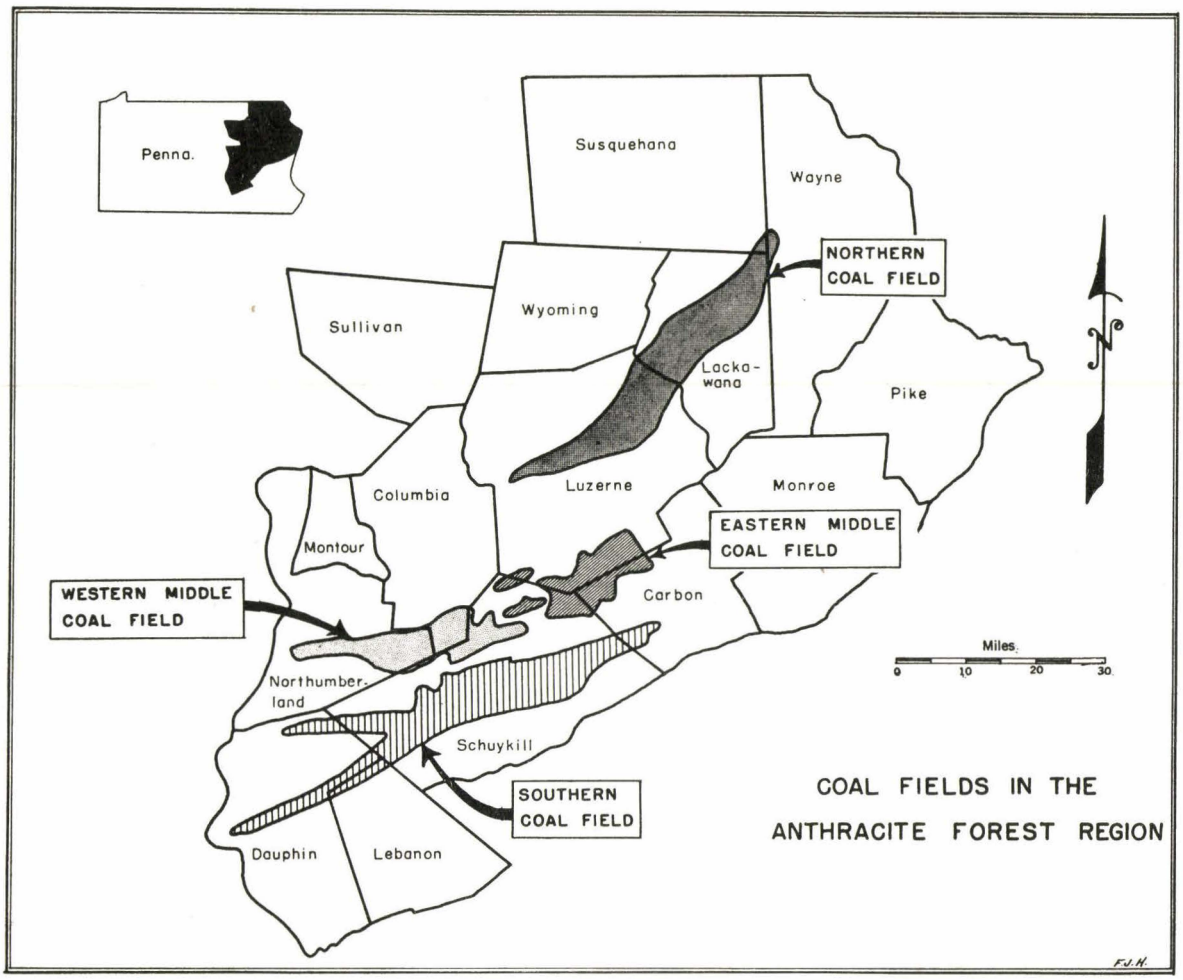
Anthracite mines in Pennsylvania use up nearly 1 cubic foot of wood for every ton of coal they produce. This proportion of wood needed by the coal mines seems to be increasing steadily.

A recent survey showed that 28 million cubic feet of round timbers and 65 million board feet of rough lumber were consumed by the mines in 1943. In that year 44 million tons of anthracite were deep-mined. This implies an average consumption of 0.64 cubic feet of round timbers and 1.5 board feet of lumber for every ton of coal produced. These figures add up to 0.97 cubic feet of wood for every ton of coal.

Table 1.--Timber used in anthracite mines in 1943

Coal field	Coal mined in 1943	Round timbers[1]		Sawed timbers[2]		All timbers	
		Total	Per ton of coal	Total	Per ton of coal	Total	Per ton of coal
	Million tons	Million cubic feet	Cubic feet	Million board feet	Board feet	Million cubic feet	Cubic feet
Northern	26.0	19.0	0.73	23.4	0.9	24.2	0.93
Eastern Middle	4.0	2.1	.52	8.4	2.1	3.8	.96
Western Middle	8.5	4.3	.51	21.2	2.5	9.2	1.08
Southern	5.5	2.7	.50	12.1	2.2	5.5	1.00
All fields	44.0	28.1	0.64	65.1	1.5	42.7	0.97

1/ Includes props, fore-poles, ties (usually faced on 2 sides), sprags, and lagging.
2/ Includes rough mine boards and structural timbers.



A sampling method was used to obtain these estimates. Twenty-four collieries, which produced one-fourth of the total amount of coal deep-mined in 1943, provided detailed records on the amount and kind of timbers used that year, and the source of the wood. All four coal fields and different sizes of collieries were represented in the samples.

Timber requirements per ton of coal vary greatly between mines, and even within individual mines. This is due to a number of factors: the thickness and general characteristics of the coal veins, the extent to which the tunnels are self-supporting, the method of mining, the use of treated timbers, and the substitution of concrete and steel for wood.

Contrary to expectations, the total cubic-foot requirements per ton are practically the same for all four coal fields in the anthracite region. But there is a difference in the ratio of round timbers to rough lumber--especially in the northern field. Here more round timbers and less lumber are used per ton of coal than in any of the other three fields. This is probably because of the many ties consumed. The coal

veins lie relatively horizontal, and a large amount of mine railroad must be constructed and maintained. In the other fields the coal veins pitch more steeply. This accounts for the use of a large volume of lumber for making boxes to catch the coal mined in the steep pitches.

In addition to ties and lumber, a large amount of wood is needed in the mines for props and lagging. Props are used to support the tunnels as the coal is taken out. Lagging is sticks 2-4 inches thick (at the small end) and 6-8 feet long; they are placed close together between the props and the mine walls and roof to prevent loose material from falling into the tunnel. About 10 percent of the round timbers used is lagging.

The survey also showed that about 90 percent of the round timbers and 75 percent of the lumber used in the mines came from the forests of the 15 counties in the anthracite region.

A correlation of the wood-requirement figures for 1943 with those determined by Brush[1/] for 1923 and 1935 and by Mesavage[2/] for 1940 indicates that the amount of wood needed for each ton of coal mined is steadily increasing:

Year	Wood needed per ton of coal mined (Cubic feet)
1923	0.61
1935	.74
1940	.85
1943	.97

This trend is due to the fact that the distance from the main shafts to the workings in the mines is constantly increasing. In addition to timbers for new workings, replacements are constantly needed in the main tunnels.

1/ Brush, W. D. Timber requirements for mines in the United States: a progress report of the forest survey. 1938. (U. S. Forest Service.)

2/ Mesavage, C. 1943. (Unpublished manuscript.)